ART. XXIX.—*The Faults of Southwest Virginia;* by JOHN J. STEVENSON, Professor in University of the City of New York.

THE existence of great faults in southwest Virginia was made known in 1836 by Professor Wm. B. Rogers, three principal faults being shown on the long cross-section appended to his "Reconnaissance."* The existence of the Saltville and New Garden faults is asserted in a paper on Thermal Springs by the same author and in a long memoir on the structure of the Appalachian Chain by Professors W. B. and H. D. Rogers.† At a much later date, Professor J. P. Lesley ran several lines across portions of the faulted area on both sides of New River

* Report of the Geological Reconnaissance of the State of Virginia, 1836.

† These papers are contained in the volume of the Transactions of the Association of American Geologists and Naturalists, 1840–42.

and added greatly to the knowledge of the general structure,* of which he first appears to have had a clear conception. Professor Safford's map of Tennessee shows the extent of the faults in that State. The writer has made a reconnaissance of the faulted region in Virginia from the Tennessee line to almost twenty miles beyond New River, a distance of 150 miles, and has given the results in several memoirs read before the American Philosophical Society.† As these last are independent, information respecting the several faults is broken in such a way that a summary statement is necessary to render it available. If more of detail should be needed, the reader is referred to the memoirs cited.

The "Great Valley" follows the northerly or northwesterly foot of the Blue Ridge from New England to Alabama and, except where broken by faults, is underlaid by Lower Silurian and Cambrian rocks. In New York, Pennsylvania and Maryland, it is bounded on the northerly side by anticlinals and synclinals carrying the newer rocks so that within a little distance one is in the Upper Devonian. The conditions are simple, there being no faults of great longitudinal extent cutting off the valley on that side. The only faults lie at a considerable distance beyond the valley and, though of much interest, are utterly insignificant in comparison with those found farther south.

At no great distance southward in Virginia, strips of Lower Silurian are shown beyond the line of the "Great Valley." These are more numerous near New River and become wider thence to the Tennessee line; while near and beyond the same river the valley itself is broken by patches of Upper Silurian, Devonian and even Lower Carboniferous rocks. These great changes are due to faults as remarkable for their longitudinal as for their vertical extent.

The greatest width of the faulted area in southwest Virginia is about forty miles, measured along a line passing through Wythe, Giles and Tazewell Counties of Virginia. The faults, separated by varying intervals, show Knox limestone on the southerly or upthrow side, while the beds on the northerly or downthrow side may belong anywhere from Lower Silurian to Upper Carboniferous. Thus the region is broken into a series of alternating "rich" and "poor" valleys, underlaid in the former by Lower Silurian limestones and in the latter by Upper Silurian and Devonian shales. The sections shown by

* Professor Lesley's papers were read before the American Philosophical Society on May 16th, 1862, and on April 21st, 1871.

† The dates of these papers are August 20th, 1880, January 21st, 1881, October 7th, 1881, November 21st, 1884, and one not yet read before the Society.

the blocks held between the faults vary much in length, the most extended being that between the Copper Creek and Saltville faults, where the column reaches from the bottom of the Knox calcareous rocks to the top of the Umbral, possibly in some places to the Coal Measures.

The blocks between the faults are not always monoclinals, as might be inferred from a hasty perusal of some papers presented prior to those of the writer; far from it. Where the blocks are broad, seven or eight miles, groups of anticlinals occur, canoe-shaped and overlapping, thus reproducing the features so characteristic of Upper and Lower Silurian areas in Central Pennsylvania. But these folds are not parallel to the faults and any relationship appearing to exist between the faults and such folds is evidently fortuitous.

Three faults entering Virginia from Tennessee, termed by the writer, the Poor Valley, the Wallen's Ridge and the Pattonsville, and having a vertical extent of 2400, 2800 and 500 feet respectively, disappear within a few miles, being simply fissures on the southeasterly side of a bold anticlinal, that of Powell-Stone Mountain, which also disappears within a short distance. The important, persistent faults are—

The Clinch Group, the Copper Creek, the Saltville, the Walker Mountain; beside which are the short faults of Draper and Price Mountains in the valley, with the cross-faults, Max Meadows and Pulaski, extending from the Draper Mountain fault toward that of Walker Mountain.

The *Clinch Group* of faults includes the Clinch Uplift and Abb's Valley fault of Professor Lesley's 1871 memoir; as the writer ran some lines between those of Professor Lesley, he has been enabled to elaborate the group somewhat and to discover a more complicated structure than was at first supposed. The group consists of—

a. The Hunter Valley fault or Clinch Uplift; *b.* The New Garden fault; *c.* The Stony Ridge fault; *d.* The Abb's Valley fault.

The Clinch Uplift enters Scott County, Va., from Tennessee, continues through that county into Russell without interruption; but midway in the latter county, after bending northward, it gives off a cross fault and holds its new course into Buchanan County where it is soon lost. The New Garden fault begins in Russell County not far from the line of Scott and almost accurately in the place where the former fault ought to have been found had its course been unchanged; it is joined by the cross fault from the Clinch Uplift and it continues through Russell and Tazewell Counties of Virginia into Mercer County of West Virginia, where it follows the northerly foot of East River Mountain to certainly twenty-five miles beyond

New River. The Stony Ridge fault begins in Russell County and continues thence through Tazewell into Mercer County of West Virginia. The Abb's Valley begins in Tazewell County and extends into Mercer County. These two faults do not appear to reach New River, but of this the writer may not speak positively as he has not crossed their place near the river. The intervals between these faults increases eastwardly.

The *Copper Creek* fault enters from Tennessee, passes through Scott County and within a few miles in Russell County disappears in the Elk Garden anticlinal, a fold with double or triple crest, which is followed easily through Russell and Tazewell Counties into Bland; but soon after entering the last county a double fault, the Winonah, arises from the anticlinal, which, at a few miles farther, gives off from its northerly side a second, that of Buckhorn Mountain. These two faults cross the New River and enter Craig County, but they evidently disappear a little way beyond, as they do not appear there in Rogers's cross-section. Where the Buckhorn fault begins, the interval to the other is only a few rods, but at New River it is almost two miles. The Winonah, like the Copper Creek fault, is in Knox, but it holds a vertical wall of white Medina in the crevice. It evidently gives off a similar branch beyond New River, for there two lines of white Medina appear in the Knox limestones.

The *Saltville* fault, the *North Holston* fault of Lesley's 1871 memoir, is, so far as the writer has been able to determine, a continuous fracture from Tennessee to thirty miles beyond New River. How much farther it extends, the writer has not yet ascertained. It is of especial interest in that its course exhibits total indifference to that of the anticlinals and to the strike of the rocks. It shows no material variation in the extent of its throw.

The fault of *Walker Mountain* enters Washington County from Tennessee as a throw in the Knox beds, but soon after entering Smyth County the throw becomes stronger and before entering Wythe County, Umbral shales are shown on the downthrow side. Thence to twenty miles beyond New River the fault remains the same. How much farther it extends was not ascertained, but like the Saltville it gives promise of many miles. One of these two is, no doubt, the "great fault" so often spoken of as following the northerly or northwesterly side of the valley.

The *Draper* Mountain fault is a short fracture in Wythe and Pulaski Counties, which brings up the Potsdam as a rugged mountain in the heart of the valley. Two cross-faults pass from it, the Max Meadows in a westward direction and the Pulaski in a northwestward direction, toward the Walker

Mountain fault; so that in the very heart of the "Great Valley" there is a block of Upper Silurian, Devonian and Lower Carboniferous with Lower Silurian on two sides, Cambrian on the third and Lower Carboniferous on the fourth.

A curious double fault, that of Price Mountain in Montgomery County, brings up a short anticlinal ridge of Lower Carboniferous midway in the valley. This V-shaped fault is short and its branches are separated by an interval of not more than three miles and a half at the widest place.

The faults do not follow straight lines and their courses show much variation. The intervals show equal variation.

As has been said already the vertical extent of a fault is not the same along the whole line. It was observed that the faults where followed out proved to be merely cracked anticlinals; the most notable illustration being found in the Copper Creek fault, which disappears in the Elk Garden anticlinal, only to reappear after a distance of seventy miles in the Winonah and Buckhorn faults, which in their turn disappear in an anticlinal. The Max Meadows, Draper Mountain, Abb's Valley faults and the three small faults of Lee and Scott Counties illustrate the matter almost equally well. Such being the origin of the fault, variation in the vertical extent must be looked for.

But the strength of the throw may be the same for a long distance while the apparent strength may be very different. The development of anticlinals on one side or the other, anticlinals belonging to a time prior to the formation of the faults, may cause the appearance of successive groups on one side. An admirable illustration is found in the Saltville fault, which has Knox limestone on the upthrow side throughout the whole distance examined, while on the downthrow side one finds the whole series from the Knox limestone to the Umbral shales, possibly to the Coal-measures. But the extent of the throw is the same throughout, the variation being due to the presence of anticlinals crossed by the fault.

The Hunter Valley fault or Clinch uplift illustrates well the variation in strength of the throw. Where it enters from Tennessee it shows Knox on the upthrow and Clinton on the downthrow side; but within a few miles Hamilton is on the downthrow, while within ten miles farther, Lower Coal-measures (Quinnimont) are in the fault on the downthrow side. The upthrow diminishes in Russell County beyond the origin of the New Garden fault so that Middle Coal-measures are in contact first with Devonian and then with Lower Coal-measures. The Walker Mountain fault illustrates the same thing equally well, for though it enters as a fault in the Knox the downthrow gradually increases until in Wythe County the whole series to the top of the Umbral is seen.

The extent of the faults, both vertical and longitudinal, is as follows:

	Vertical.	Longitudinal in Virginia.
Poor Valley	2,400′ to 0′	40 miles.
Wallen's Ridge	2,800′ to 0′	25 "
Pattonsville	500′ to 0′	20 "
Clinch Group—		
a. Hunter Valley	8,500′ to 0′	65+ "
b. New Garden	7,500′ to 0′	102+ "
c. Stony Ridge	2,300′ to 0′	50+ "
d. Abb's Valley	1,700′ to 0′	40+ "
Copper Creek, etc.	3,000′ to 0′	45 "
Saltville	10,000′ to 500′	130+ "
Walker Mountain	10,000′ to 1,000′	130+ "
Max Meadows	9,800′	20 "
Pulaski	9,600′	8 "
Draper Mountain	12,500′ to 0′	20 "
Price Mountain	10,000′	10+ "

The conditions in the immediate vicinity of the apparent fault lines are not easily ascertained, for ordinarily the line of contact and the area to a considerable distance on each side are covered by rubbish. More than that: the thrust has been sufficient to shove the upthrown beds to a considerable distance over on the downthrown beds as is shown by the Hunter Valley fault on Big Stony Creek in Scott County, so that the place of the fault is necessarily somewhat obscure. That the faults are practically cracked anticlinals, however, is sufficiently evident from their origin and disappearance; but traces of the anticlinal structure are not wanting along the faulted lines. Thus the great Clinch or Hunter Valley fault shows, near the Tennessee line, Clinton and Knox in contact but each dipping from the fault. A similar structure was seen thirty miles farther eastward, where Lower Carboniferous and Devonian are upturned on the northerly side of the fracture; while still farther east the Lower Coal-measures (Quinnimont) are shown on the northerly side dipping away from the fault at sixty to seventy degrees, with the Knox beds on the other side also dipping away from the fault but at a less rate. But the conditions vary, and at several localities along this fault the dip on the downthrow side is toward the fault, the thrust evidently having been sufficient to carry the upthrown rocks over the line to a considerable distance. This is apparently the condition along the Walker Mountain fault everywhere within the area examined; for the conformability is so close that the existence of a fault would not be suspected by one depending only on the local stratigraphy.

Rocks in the immediate vicinity of the apparent fault line—

where the upthrown and downthrown rocks are in contact—frequently show no signs of disturbance other than abrupt dip; but the proof of disturbance is much more distinct on the upthrow side at a distance of somewhat more than half a mile and beyond; while even on the downthrow side the dip may be greater at some distance than it is at the fault line itself. Where New River crosses the Walker Mountain fault, the dip on the downthrow is fourteen or fifteen degrees, but at barely half a mile farther down the stream, the dip is fifty-five degrees; yet within fifteen miles toward the east, the conditions are altogether reversed, the shales dipping very abruptly near the fault, while, at about one-fourth of a mile away, the sandstones are dipping at but twenty-five degrees.

But on the upthrow side the disturbance in any case is not confined to mere variations in rate of dip; the crushing is proved by numerous narrow, crowded, abrupt folds, beginning at half a mile or so from the fault and continuing for even a mile or more. These are especially noteworthy near the faults of the Clinch Group, but they are shown in some places near the Walker Mountain fault. The crushing at several localities near Clinch River is excessive and at one locality the shales are folded as closely as micaceous shales on Manhattan island, but they show no evidence of metamorphism.

That the faults are closely related in several instances to anticlinals has been stated already more than once; but a system of folds still remains, though in fragments, with which the faults have but a fortuitous connection. The conditions cannot be exhibited here without the aid of somewhat complicated diagrams; but the colored maps accompanying the writer's memoirs already cited make the matter sufficiently clear.

The Saltville fault, best of all in Virginia, shows the conditions, for it cuts off several folds existing in the interval between it and the Copper Creek fault at the north, a space ten to twelve miles wide. The first fold at the west, the "Great Garden" axis of W. B. Rogers, is an inverted canoe, about eighty miles long and attaining its maximum in Burk's Garden of Tazewell County. As the fault does not follow the strike but simply cuts along the side of the canoe, it is clear enough that the section on the northerly or downthrow side must show noteworthy variations as the line approaches or leaves the higher, wider portion of the canoe, while no change is shown on the opposite or upthrow side. And this is the condition; for while the Knox limestone is on the upthrow side throughout, changes enough appear on the other side. Thus in Washington County opposite Mendota, the width of Lower Carboniferous is nearly four miles, in which a magnificent section of Umbral and Vespertine is shown. But at the edge of

Bland and Smyth Counties, where the Garden fold is greatest, the strip of Lower Carboniferous is barely half a mile wide and the presence of both divisions is due only to a remarkable decrease in thickness of the Umbral. As the anticlinal diminishes, the width of Lower Carboniferous increases; but the higher rocks are not reached, for within fifteen miles in Bland County, the fault cuts off the Kimberling anticlinal near its origin.

This fold rapidly increases in height and under its influence Lower Carboniferous rocks soon disappear from the downthrow side and the Knox is in contact with Lower Devonian near the line between Bland and Giles Counties. A third anticlinal, the Sinking Creek, is cut by the fault a little farther on; and as it increases in height, the Knox is brought into contact with the successive groups of the Upper Silurian, with the Hudson, the Trenton, and finally with the upper Knox before New River has been reached; while beyond that river, the diminution of the fold permits the presence of Trenton, Hudson, and, before the eastern limit of Giles County has been reached, of Medina on the northerly side of the fault.

The axes of these anticlinals are approximately parallel and make a considerable angle with the fault.

A similar condition exists in the curious block within the Great Valley enclosed by the Walker Mountain, Draper Mountain, Max Meadows and Pulaski faults. The Walker Mountain fault cuts off, in succession, Lower Silurian, Upper Silurian and Devonian on the upthrow side, while on the downthrow side Umbral shales are shown continuously. Within the block is an anticlinal which apparently is in no way connected with any of the folds observed in the Knox beds outside of the block.

The Great Cove fault of Fulton County, Pennsylvania, as described by the writer* shows, as far as it goes, equally well with the Saltville, this indifference to the course of the pre-existing folds. The Cove anticlinal, like the Garden axis, is an inverted canoe with its eroded cove surrounded by a wall of Medina. The fault, which holds a jagged wall of Medina in the crevice, makes but a small angle with the axis of the anti-

*Second Geol. Surv. of Penn. Rep. on Bedford and Fulton Counties, p. 55. This reference affords an opportunity of satisfying the "long-felt want" of some acquaintances, who are at a loss to reconcile my maps of these counties as appended to the report with the maps of the same counties as given in the Geological Atlas of Penusylvania. The maps *cannot* be reconciled. Those appended to the geological report on the counties are by the writer, except in so far as they refer to the Broad Top region, and, except in so far as they refer to that region, they are fairly good. The maps in the Geological Atlas, though credited to me, were not made by me in any sense whatever; they were printed three years or more before I even thought of doing any work in Bedford and Fulton Counties.

clinal, but sufficient for curious variations, as may be seen by consulting the writer's map of Fulton County.

The facts that have been given lead the writer to the conclusion that the faults are of later date than the system of folds and that they may have been produced at a time possibly as late as the era of Mesozoic disturbance marked by dikes throughout the Triassic area of the Atlantic border.